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***published in***

Zeitschrift fur Gerontologie und Geriatrie  
2003

***DOI (link to publisher)***

[10.1007/s00391-003-0143-8](https://doi.org/10.1007/s00391-003-0143-8)

***document version***

Publisher's PDF, also known as Version of record

[Link to publication in VU Research Portal](#)

***citation for published version (APA)***

Graafmans, W. C., Lips, P. T. A. M., Wijlhuizen, G. J., Pluijm, S. M. F., & Bouter, L. M. (2003). Daily physical activity and the use of a walking aid in relation to falls in elderly people in a residential care setting. *Zeitschrift fur Gerontologie und Geriatrie*, 36(1), 23-28. <https://doi.org/10.1007/s00391-003-0143-8>

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## Daily physical activity and the use of a walking aid in relation to falls in elderly people in a residential care setting

### Zusammenhang zwischen Stürzen, täglichen körperlichen Aktivitäten und dem Gebrauch von Gehhilfen bei älteren Menschen in Altenheimen und Betreutem Wohnen

■ **Summary** Physical activity is usually considered as an important component of a healthy lifestyle, including a preventive effect on the risk of falls in the elderly. The relationship between physical activity and falls is complex: physical activity is a prerequisite to maintain neuromuscular functioning, necessary to keep balance and to react to a fall, but a higher level of

physical activity also implies a greater exposure to environmental threats, possibly leading to a fall. Related to this greater exposure to threats, the use of a walking aid may protect against falls in those who have impaired mobility.

In this cross-sectional study we investigated the relationship between daily physical activity and falls and the use of a walking aid in elderly subjects. Participants were 131 men and 563 women, aged 70 years and over (mean age and standard deviation:  $82 \pm 6$  years), living in homes for the elderly ( $n = 335$ ) and apartment houses for elderly ( $n = 359$ ). Data on baseline characteristics and falls in the previous year were obtained using a questionnaire. The level of daily physical activity in the previous year was obtained by means of a questionnaire regarding household and leisure activities. Subjects with a lower extremity fracture in the previous year were excluded from the analyses. Data were analysed using multiple logistic regression, adjusted for age, gender, and residence. In the past year, 40% of the participants fell at least one time, and 19% of the participants fell two times or more. Since falls and recurrent falls were nonlinearly related to the level of daily physical activity, the physical activity score was grouped into quartiles: the highest quartile cor-

responding to the highest activity level. Odds ratios (and 95% confidence intervals) for falls and recurrent falls for subjects in the highest quartile contrasted with those in the lowest quartile were 0.5 (0.3–0.9) and 0.3 (0.2–0.6), respectively. The risk of falls and recurrent falls was not lower for those with intermediate levels of daily physical activity. The use of a walking aid protected against falls in those with intermediate high activity levels (third quartile). It was suggested that the exposure to environmental hazards, due to some degree of physical activity may have been responsible for the nonlinear relationship between daily physical activity and falling. We conclude that a high activity level and the use of a walking aid may protect against falls.

■ **Key words** Physical activity – falls – walking aid – elderly subject – risk of falling

■ **Zusammenfassung** Körperliche Aktivitäten stellen einen wichtigen Bestandteil für einen gesunden Lebensstil dar. Dies gilt auch für die Sturzprävention. Der Zusammenhang zwischen körperlicher Aktivität und Stürzen ist komplex. Körperliche Aktivität ist zum einen notwendig um die neuromuskuläre Funktion und Balance aufrechtzuerhalten und

Received: 28 October 2002  
Accepted: 15 November 2002

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um auf einen Sturz zu reagieren, aber ein höheres Ausmaß körperlicher Aktivität bedeutet auch ein größeres Risiko aufgrund der Umgebungssituation zu stürzen. Gehhilfen stellen möglicherweise einen Schutz vor Stürzen bei gehbehinderten Menschen dar. In einer Querschnittsuntersuchung wurde daher der Zusammenhang zwischen täglicher körperlicher Aktivität und Stürzen und dem Gebrauch von Gehhilfen bei älteren Menschen untersucht. Teilnehmer der Studie waren 131 Männer und 563 Frauen, 70 Jahre und älter (mittleres Alter  $62 \pm 6$  Jahre), die in Altenheimen ( $N=335$ ) und Betreutem Wohnen ( $N=359$ ) lebten. Grundlegende Daten und die Sturzhäufigkeit im vergangenen Jahr wurde durch einen Fragebogen ermittelt, ebenso die durchschnittlichen täglichen

körperlichen Aktivitäten. Personen mit einer Fraktur der unteren Extremität im vergangenen Jahr wurden von der Untersuchung ausgeschlossen. Die Daten wurden durch multiple logistische Regression angepasst für Alter, Geschlecht und Wohnort analysiert. Im letzten Jahr stürzten 40% der Teilnehmer mindestens einmal und 19% der Teilnehmer zweimal oder mehr. Da Stürze und wiederholte Stürze nicht linear mit dem Ausmaß körperlicher Aktivität verknüpft sind, wurde der körperliche Aktivitätsscore in Quartilen unterteilt, wobei die höchste Quartile den höchsten Aktivitätslevel widerspiegelt. Die Odds-ratio (und 95% Konfidenzintervalle) für Stürze und wiederholte Stürze kontrastierten mit 0,5 (0,3–0,9) in der höchsten Quartile verglichen mit der nied-

rigsten Quartile, die ein Verhältnis von 0,3 (0,2–0,6) aufwies. Das Risiko für Sturz und wiederholte Stürze war für Teilnehmer mit mittlerem Aktivitätsniveau nicht geringer. Der Gebrauch von Gehhilfen stellte in der Gruppe mit intermediärem bis hohem körperlichem Aktivitätslevel (3. Quartile) einen Schutz vor Stürzen dar. Es wird vermutet, dass Umgebungsrisiken verbunden mit einem gewissen Maß körperlicher Aktivität verantwortlich sind für die nichtlineare Verbindung zwischen täglicher körperlicher Aktivität und Stürzen. Ein hoher Aktivitätslevel und der Gebrauch von Gehhilfen kann dazu beitragen, Stürze zu vermeiden.

■ **Schlüsselwörter** Körperliche Aktivität – Stürze – Gehhilfen – ältere Menschen – Sturzrisiko

## Introduction

Falls are a major problem in the elderly, causing injury, fear of falling and consequently social isolation. Besides bone fragility, falling is the major factor causing fractures (1–3). Among the elderly, approximately 1 to 3 percent of falls results in a hip fracture, and over 90 percent of hip fractures are caused by a fall (4–6). Falls also may lead to various other types of fractures, soft tissue injury, head traumas, and increased mortality (7, 8). The cumulative incidence of falling among elderly people varies between 30 percent and 50 percent over a 1-year period (6, 9–12). This variation partly results from differences in study populations, as regard to e.g., age and health status. Falling is a multifactorial problem due to both extrinsic (environmental) and intrinsic risk factors. In general, mobility impairment, diminished balance, cognitive impairment, and the use of sedatives have been identified as important risk factors for falls in previous studies (6, 9, 12–14).

A potential risk factor, which has not been given much attention, is physical activity or a lack of physical activity. Usually a lack of physical activity is regarded as a risk factor for falls (15), and physical activity has been a successful intervention to prevent falls in several studies (16, 17). However, not all stud-

ies have demonstrated a preventive effect of physical activity on falls (18–21). The relationship between physical activity and falls is probably complex: physical activity is a prerequisite to maintain neuromuscular functioning, necessary to maintain balance and to react to a fall, but a higher level of physical activity also implies a greater exposure to environmental threats, possibly leading to a fall. A walking aid may protect against falls in those with an imbalance between physical capacity and physical activity level. The relationship between physical activity and falls may be modified by the level of mobility. While mobile persons may benefit from high physical activity levels, the less mobile persons may increase their risk of falls by high levels of physical activity (22).

With advancing age, daily physical activities with low intensity such as housekeeping, shopping and leisure activities increasingly determine the total amount of physical activity since occupational activities and high intensity activities decline with age (23). The relationship between daily physical activity and falls and the role of the use of a walking aid remains to be established. Insight in this relationship may help to develop guidelines for an optimal and safe activity pattern for elderly people. In this cross-sectional study we examined daily physical activity and the use of a walking aid in elderly people in relation to falling.

## Methods

### ■ Subjects

During a one-year period, 710 elderly (132 men and 578 women) were recruited from seven homes and seven apartment houses for the elderly in Amsterdam and its vicinity (The Netherlands) to participate in this study. In Dutch homes for the elderly, some care is provided, but less than in a nursing home. People in homes for the elderly are supported in their daily activities, such as, meals are provided, support in washing and dressing, support in medical treatments, and management of medication. Care is given by professional caregivers, often managed by a trained nurse. Medical attention by a physician is not organised inside the homes for the elderly. People who live in apartment houses for the elderly live independently, but they can ask for help when necessary, meals are served on request, and their houses offer special safety measures, including an alarm system. The independence of people in apartment houses is less compared to community-dwelling elderly. Care is usually provided by an adjacent home for the elderly. Inclusion criteria were age 70 years or older and no severe cognitive impairment, as judged by the personnel of the care facility. Informed consent was asked from the participants. The protocol was approved by Medical Ethics Committee of the Academic Hospital of the Vrije Universiteit, Amsterdam.

### ■ Measurements

Data on daily physical activity in the previous year was obtained using a validated questionnaire for elderly persons (24). Frequency (times per week and months per year) and duration of different activities were registered: household activities (e.g. cleaning and shopping), sports activities (e.g. swimming and cycling) and leisure activities (e.g. going for a walk). For each activity the energetic expenditure was calculated and subsequently a score was calculated by summation of all activities for each person during the past year (24). The activity score in a previous study in elderly people ranged from 2 to approximately 30 (24). Falls in the previous year, the time of the fall and the place were checked by a trained research assistant during an interview using a structured questionnaire. If there was any doubt about the reliability of the registration, a nurse or caregiver of the residence was consulted. Participants were classified as “fallers” if they experienced at least one fall and as “recurrent fallers” if they experienced at least two falls during the past 12 months. By identifying subjects as “recur-

rent fallers” ( $\geq 2$  falls) we may avoid some bias. Single falls may be the result of a unique unfortunate situation, not related to any systematic pattern, such as the relationship with physical activity. Information on several variables was collected by the research assistant during the interview: type of residence, the use of a walking aid, and age.

### ■ Data analysis

The relation between falls and the level of daily physical activity was examined by means of logistic regression analysis. Adjustments were made for age, gender and residence. Two outcome variables were defined: “fallers” ( $\geq 1$  fall) were contrasted with “non-fallers,” and “recurrent fallers” ( $\geq 2$  falls) were contrasted with participants who had no falls or only one fall ( $\leq 1$  fall). Since the level of physical activity was not linearly related to falls or recurrent falls, the physical activity score was analysed as a categorical variable. For this purpose subjects were grouped into four categories according to quartiles. Those in the lowest quartile were the least active and those in the upper quartile the most active subjects. Any difference among the categories in their relationship with falls and recurrent falls was tested (Chi-square test), and odds ratios (OR) (and 95% confidence intervals (CI)) were calculated for each category in contrast to the lowest activity category (reference category). Age was also non-linearly related to falls and was included in logistic regression analyses as categorical variable involving quartiles. Fractures are usually the result of a fall and especially lower extremity fractures may lead to immobilisation and thereby affect the level of physical activity substantially. Therefore, subjects who had suffered a hip or other lower extremity fracture as a consequence of a fall during the past year were excluded from the analyses. The relationship between daily physical activity and falls was analysed separately in those using a walking aid (including occasional use of a wheelchair) and those not using a walking aid. Adjusted odds ratios for the relationship between physical activity and falls were presented on a logarithmic scale, which makes a more straightforward interpretation possible of the logistic model with symmetrical confidence intervals.

## Results

During a one-year period, 710 subjects were recruited for this study. As a consequence of a fall 16 subjects had suffered a hip or other lower extremity



**Table 1** Number of participants with falls (40%) and recurrent falls (19%) in the past year

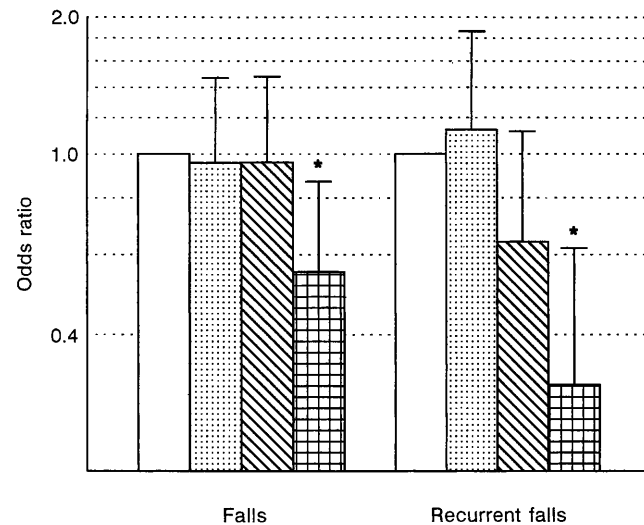
Number of falls	Number of participants and Percentage of study population
No fall	416 (60%)
1	149 (21%)
2	66 (10%)
3	28 (4%)
4	14 (2%)
>5	21 (3%)

fracture during the previous year. These subjects were excluded, leaving 694 subjects for analysis. Subjects (131 men and 563 women) were residents of homes for the elderly ( $n=335$ ) and apartment houses for the elderly ( $n=359$ ). Mean age and standard deviation (SD) were  $82.8 \pm 5.9$  years. Walking aids or wheelchair were used by 333 subjects (48%), i.e. cane ( $n=178$ ), walker ( $n=137$ ), and occasionally use of wheelchair ( $n=18$ ).

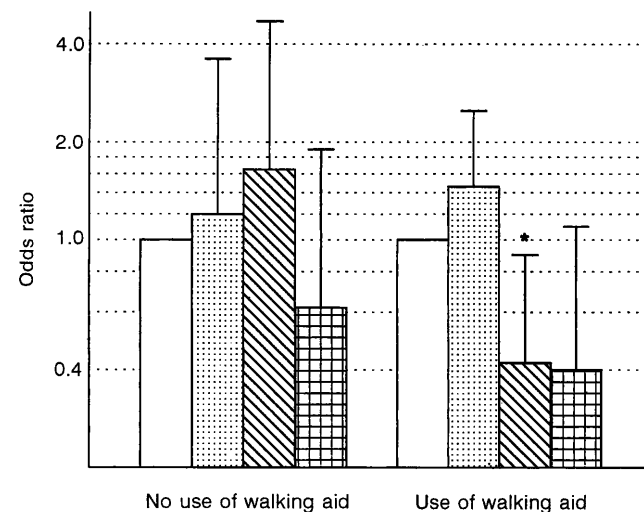
In the previous year, 597 fall accidents were reported by 278 participants (40%). Table 1 shows the number of participants with falls and recurrent falls in the past year. Recurrent falls were found with 129 participants (19%). The majority of falls (72%) occurred indoors.

The daily physical activity score ranged from 0.0 to 22.8, median value and interquartile range were 3.0 (1.4–5.8). The median and interquartile range of the physical activity score in the first quartile was 0.7 (0.0–1.0), in the second quartile 2.1 (1.8–2.5), in the third quartile 4.0 (3.5–4.7), and in the fourth quartile 7.9 (6.8–9.6). Two points on the physical activity score represent for example approximately 1 hour walking or cycling per week. The unadjusted odds ratios (OR) and 95% confidence intervals (CI) for falls in the second, the third, and the fourth quartile of the physical activity score, compared to the first quartile were 0.9 (0.6–1.4), 0.9 (0.6–1.3), and 0.5 (0.3–0.8), respectively. For recurrent falls these odds ratios were 1.1 (0.7–1.8), 0.6 (0.4–1.1), and 0.3 (0.2–0.6), respectively. After adjustment for age, gender and residence, the categories of daily physical activity were still differently related to falls ( $p=0.03$ ) and recurrent falls ( $p=0.0007$ ) (Fig. 1). The use of a walking aid was associated with falls (OR (95%CI); 2.1 (1.5–2.8)) and recurrent falls (OR (95%CI); 2.6 (1.7–3.8)).

Categories of daily physical activity were differently related with recurrent falls in those using a walking aid ( $p=0.005$ ) and in subjects who did not use a walking aid ( $p=0.10$ ) (Fig. 2). In the third quartile, corresponding the category with the second highest activity level, the difference between either



**Fig. 1** The odds ratios (depicted on a log-scale) for falls and recurrent falls adjusted for age, gender, and residence in quartiles of the daily physical activity score. The left bars (open) represent the lowest quartile, indicating the reference group, the second up to the fourth bar to the right represent the other quartiles with increasing activity scores. The error bars represent the upper half of the 95% confidence intervals. \* $p < 0.05$ , significantly different from the lowest quartile (reference)



**Fig. 2** The odds ratios (depicted on a log-scale) for recurrent falls in quartiles of the daily physical activity score for subjects using a walking aid (including occasionally use of a wheelchair) and those not using a walking aid. The left bars (open) represent the lowest quartile, indicating the reference group, the second up to the fourth bar to the right represent the other quartiles with increasing activity scores. The error bars represent the upper half of the 95% confidence intervals. \* $p < 0.05$ , significantly different from the lowest quartile (reference)

using a walking aid or not, was most pronounced. The odds ratio (and 95% confidence interval) for falls in this third quartile compared to the least active quartile was 1.7 (0.6–4.7) for those not using a

walking aid and 0.4 (0.2–0.9) when using a walking aid. The relationship between physical activity and falls is modified by using a walking aid. Similar relationships were found between daily physical activity and falls ( $\geq 1$  fall).

## Discussion

This study showed a non-linear relationship between physical activity and the risk of falls. Those with the highest activity level had a significant lower risk of falls, but those with intermediate levels were not protected against falls. The use of a walking aid protected against falls in persons with high intermediate levels of physical activity.

The non-linear relationship between physical activity and the risk of falling is based on contrasting relationships: on the one hand physical activity protects against falls by maintaining neuromuscular function, and on the other hand physical activity introduces a higher risk due to higher exposure to risk-bearing situations. The balance in these contrasting effects is such that with increasing activity there is first no change in the risk of falls and only the very active seem protected. Subjects in intermediate categories of physical activity may be especially at risk for a discrepancy between physical ability and physical activity (more active than able), possibly resulting in falls. Previous studies have shown that falls are more likely in subjects with intermediate physical ability (25, 26). The non-linear relationship between daily physical activity and falls, found in this study, may be in agreement with the lack of decrease of fall incidence in some other studies following physical training (19, 21). It has been shown that physical activity programs in frail elderly increase the level of spontaneous daily physical activity and a reduction in the use of a walker (27, 28). These unintended changes due to intervention programs may increase the risk of falls by risk-bearing situations. The use of a walking aid may diminish the impact of these risky situations. The relationship between daily physical activity and recurrent falls was examined separately for those using a walking aid and those not using a walking aid, using the same assignment of participants to the categories, ir-

respective of the use of a walking aid. Subjects with similar activity levels in the second highest quartile may be protected against falls by using a walking aid. This is supported by the finding that high levels of physical activity are associated with a low risk of falls in persons with high ADL scores, but with a high risk of falls in those with impaired ADL function (22).

Suggesting causal relationships in a cross-sectional study involves some potential methodological flaws. Besides physical activity many other factors affect the risk of falls, and the relationship between physical activity and falls is not a simple cause and effect relationship. It has been shown that fear of falling in elderly leads to less physical activity (29, 30) and nonparticipation in recreational physical activities (31). To approximate a uni-directional relationship between physical activity and falls, subjects who suffered a lower extremity fracture during the last year were excluded from the analysis. A fall resulting in a lower extremity fracture is very likely to reduce the level of physical activity following the fracture. However, no adjustments were made for other serious fall injuries leading to reduced physical activity. Adjustments were made in multiple regression models for age, sex, and residence, indicating the general state of health and autonomy of functioning.

These results suggest a protective effect of a high level of daily physical activity for falls. However, physical activity in this highly aged population may also be a measure for the level of physical activity in the past. It may be difficult to show independent relationships for past and present physical activity since they are strongly related, as may be expected from a lifestyle factor.

This study suggests that elderly people with high levels of daily physical activity may be protected against falls. Intermediate levels of daily physical activity were not associated with a lower risk of falls, possibly due to a combination of lower physical ability and higher levels of exposure to risk-bearing situations. The use of a walking aid may protect moderately active people from falling. The results of this study emphasises the complex relationship between daily physical activity and falls and may contribute to the development of guidelines for an optimal and safe level of daily physical activity in elderly people.

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